Candidate and Supervisor experiences of doctoral study in a structured, interdisciplinary training environment

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Abstract
This study aimed to understand doctoral candidates' and supervisors' positive and negative experiences of undertaking a doctorate in a structured interdisciplinary research environment. Interviews were held with 16 candidates and eight supervisors involved in an interdisciplinary research centre. Most candidates were undertaking a disciplinary focussed doctorate while being active participants in the centre's doctoral education program. Our findings highlighted three themes that influence positive or negative experiences: the design of the interdisciplinary environment; the critical role of communication; and the qualities of candidates and supervisors deemed important to work effectively in such an environment. We conclude with suggestions that might help develop an effective interdisciplinary research environment.

Keywords
doctoral education, PhD, interdisciplinarity, research environment, communication

Background
This study examines the experiences of doctoral candidates and supervisors working in an interdisciplinary research environment. The research environment aimed to bring together different academic disciplines and interdisciplinary research approaches within a clearly articulated research theme. The focus for the study was a Centre for Doctoral Training (CDT) established as part of a university research institute and which aimed to support and develop doctoral candidates with the skills to effectively solve multifaceted problems.

Members of the CDT, who undergo a selection process, conduct individual doctoral projects based on a single academic discipline. However, all projects are undertaken within the CDT's wider interdisciplinary training environment. This environment is specifically designed to enhance candidates' doctoral research experiences whilst providing insights into the research issues from multiple perspectives.

Candidates within the CDT participate in a range of activities specifically designed to develop researcher skills and include:

- weekly lunchtime sessions where candidates present their research to peers from various disciplines;

- participation in an annual interdisciplinary team project;
- attendance at research seminars;
- involvement in training courses;
- contributing to debates and workshops; and
- exploration of interdisciplinary links between science and society.

Additionally, candidates are supervised by academic staff who have chosen to participate in the interdisciplinary Institute for their own research while also undertaking disciplinary research.

Issues related to Interdisciplinary research

There is a broad literature on interdisciplinary research at the doctoral level ranging from the individual candidate undertaking a multi/ interdisciplinary doctorate (see Gardner, 2011; Holley, 2009; Manathunga, Smith & Bath, 2004) through to research on candidates undertaking doctoral research in a specifically designed interdisciplinary environment (Mallaband, Staddon, & Wood, 2017; Schuitema & Sintov, 2017).

From the literature related to the individual candidate where she/he straddles two or more disciplinary units the research (for example, Blackmore & Nesbitt, 2008; Boden, Borrego, & Newswander, 2011) suggests that many candidates struggle with bringing together different disciplinary traditions and approaches. Reidy (2016) suggests that doctoral candidates can pursue integration of their research, but success is often limited by individual capacity, time and institutional structures; similar issues have been raised by others (see for example: Gardner et al, 2014; Holley, 2015; Taylor, 2013).

However, before moving on to examine the research related to candidates working in interdisciplinary environments we begin with a more basic issue, and that is, what is a discipline and how might we understand interdisciplinarity?

Becher and Trowler (2001) in their early work argued that within the various disciplinary 'tribes and territories' there are differences in approaches to research. This is supported by work by Golde and Walker (2006) who suggest that one aspect of doctoral education is preparing 'Stewards of the Discipline' and Walker et al (2008) with the formation of scholars. However, in more recent work Trowler, Saunders, and Bamber (2014 p. 34) suggest that: "The key point about conceptualising disciplines from a social practice perspective is that disciplines are not singular in character, and are not 'things'. Disciplines are enacted as social practices are performed and as micropolitics are played out."

Over the past 20 years there has been a substantial increase in research related to the emergence of interdisciplinary research. Trowler et al (2014) note this increase which they suggest is generally argued as a tool for solving multifaceted problems faced in our world today. As a result, they suggest that knowing the various disciplinary boundaries and approaches is a critical component of an effective interdisciplinary research culture. This leads to the question, how might we help candidates learn about these various research cultures and the boundaries involved so that disciplinary approaches can be recognized, respected and often crossed?

Enabling doctoral candidates to understand research cultures, and in the case of this study, an interdisciplinary research culture, is a complex task but can be assisted with an

understanding of the concept of ‘culture’. Lonner and Malpass (1994, p. 89) describe culture as:

> analogous to knowing the 'rules of the game'. When one becomes socialized…and enculturated (through subtle informal learning) in a specific society, he or she has learned a complex set of explicit as well as implicit rules concerning how he or she should behave among his or her fellows who share the same culture by virtue of being raised under the same rules.

Understanding the various cultural variations is important for the study reported here, given that the candidates are undertaking discipline-related research but within an interdisciplinary research environment. In this case, this is where “Interdisciplinarity is more generally acknowledged as a situation where disciplines interact and learn from each other” (Land, 2014, p.178).

As outlined above, one way of undertaking research is for the individual candidate to undertake a doctorate that involves two or more disciplines, however, the study reported here was interested to learn of the experiences of candidates undertaking a disciplinary PhD within an interdisciplinary environment. Within this context, we were led to consider what learning experiences might contribute to a successful interdisciplinary research experience. Furthermore, we were interested in understanding an environment where one can develop shared insights, skills, and knowledge, potentially synthesising the elements from different disciplines. As Millar (2013) suggests graduates with interdisciplinary PhDs are now more likely to have an increased possibility of getting a job in higher education. He also suggests that “interdisciplinary dissertation research is associated with having a higher number of publications than in non-interdisciplinary dissertation research” (p. 1163) suggesting that the need to better understand and support interdisciplinary research is growing.

However, as the research suggests, operating within an interdisciplinary research culture is not without its challenges. The obvious issues for academics in institutions largely based on disciplines tend to relate to publications, examination and employment. For example, the 2014 UK Research Excellence Framework assessed research that was grouped into 36 units of assessment largely following traditional disciplinary groupings (REF, 2014) (and it is likely to be similar for REF 2021). Furthermore, not only are there issues in research categorisation and publication but there are issues related to thesis and dissertation examination and career opportunities.

It was within this challenging research environment that the research reported here was undertaken.

Research purpose and Methods

In light of the above, the overarching aim of our research was to investigate the engagement of candidates and supervisors (who were not matched pairs) within an interdisciplinary research environment and how this was experienced by participants. Given that the aim was to understand the experiences of candidates and supervisors, the use of semi-structured interviews was considered an appropriate data collection method (Corbin & Straus, 2008; Flick, 2009).

The overall study was undertaken in two parts: an initial small-scale study and then a larger study. The initial study was undertaken with six volunteers; three candidates and three supervisors, who came from different disciplines, stages of candidature and supervisory

experience. Each was interviewed, five by Skype and one by phone using a semi-structured protocol. The interviews lasted between 20-30 minutes and were recorded and then written up to assist in analysis. To protect the identity of participants the interviews were conducted by a researcher who had no specific involvement in the management of the CDT. In line with the ethics approval, the Director of the CDT had no access to recordings or transcripts.

The initial study identified different ways in which doctoral candidates and their supervisors perceived and experienced the CDT interdisciplinary environment. The results of the pilot (Halliday & Kiley, 2016) strongly suggested that it was worth broadening the study to a larger group. The broader study followed the same protocol as the earlier study other than that the interviews were undertaken face-to-face and in three cases interviewees chose to be interviewed in very small groups rather than individually.

For analysis and reporting, the details of both studies have been addressed as an integrated study. Non-identifying details of the 16 candidate and 8 supervisor interviewees, from both studies are outlined in Table 1. As is clear, there were substantially more STEM than HASS participants and this reflects the overall composition of the CDT.

Table 1 Details of academic staff and candidates interviewed by discipline and gender

	Supervisors		**Candidates**		**Total**
Discipline	**Male**	**Female**	**Male**	**Female**	
Physics (STEM)	1	0	0	0	1
Engineering (STEM)	3	0	3	2	8
Earth Sciences (STEM)	0	0	4	2	6
Chemistry (STEM)	1	0	1	0	2
Mathematics (STEM)	1	0	0	0	1
Geography (HASS)	1	0	2	1	4
Anthropology (HASS)	0	1	1	0	2
	7	**1**	**11**	**5**	**24**

A Grounded Theory approach to analysis was used (Corbin & Strauss 2008). Following the coding of various comments from the recordings they were then clustered into main themes and concepts as reported below. Direct quotations that illustrate the various concepts have been included as examples.

To maintain anonymity in reporting any direct quotations the following protocol is used. Can6_STEM indicates a candidate within the Science, Technology, Engineering and Mathematics disciplines. Similarly, Sup4_HASS describes a supervisor from the Humanities, Arts and Social Sciences. Numerals do not indicate instances of supervisor-candidate pairings. Finally, where a comment comes from the small group discussions, all of which were in STEM, it is noted as Group1/2/3_STEM.

In the findings reported later in this paper there are some obvious differences between STEM and HASS participants, particularly with regard to communication. While recognizing these differences this paper does not specifically explore these disciplinary variations, but

recognises the need for additional research in this area. For example, Mallaband et al (2017) examine the issue of communication across disciplines. In their case this addresses social scientists who are reporting in science journals and the need for some journals to provide: "a 'safe space' for social scientists to publish research specific to their discipline" (p. 107).

Findings

The analysis of the interviews with candidates and supervisors identified three main specific themes that influenced their experiences:

1. the impact of the environment;
2. the critical role of communication; and
3. the qualities of candidates and supervisors working in such an environment.

The Impact of the environment

From the data there were four main aspects of the environment that were important in candidate learning:

a) the interdisciplinary nature of the environment;

b) the role of a community of scholars;

c) the institutional environment; and

d) the overall benefits and challenges of working in such an environment.

<u>Interdisciplinary nature of the environment and activities provided</u>

A number of comments were made regarding the different disciplines within an interdisciplinary environment and whether it was easier for some to work in interdisciplinary ways. For example: "I am not sure, but it is possible that students in the sciences where there are set techniques etc. might have less flexibility for interacting than those in the social sciences" (Can1_STEM). This view was extended by Can2_STEM with: "Interdisciplinary research lends itself better to some topics than others [and you] need to pick the disciplines carefully as some seem to work better than others." Sup1_STEM suggests that while an interdisciplinary approach: "is much more challenging than it has the right to be…[and] more time consuming [we] need to find areas that are not too divergent [for interdisciplinarity] to work".

The mini-projects, discussions at the Friday lunch-time seminars, and site visits were reported as effective ways of addressing various interdisciplinary issues.

> The CDT does the mini-project where you work with others and you have to present a series of presentations. This is brilliant because it helps you get around one particular topic and how all these different disciplinary approaches help you understand the project and that your view is not the only view. (Can4_HASS)

There was general agreement that the discussions following the Friday presentations were particularly helpful.

> I always find the best value I get is the questions and discussion afterwards because then you see the Earth Science person who will ask a different question than I would ask. I might ask, 'How deep can you drill?' and they will say 'What type of rocks are you going through?' and it is stuff like that. (Can6_STEM)

The site visits allowed candidates to see the research they were undertaking being applied in practice. “For me, who has been playing on the bench, seeing something working which had been a research project five, ten years earlier, and here it is on the big scale, it gives you a bit of faith actually” (Can7_STEM).

Candidates suggested that the enrichment activities were very helpful in seeing their work in different contexts as well as to learn about other subjects. “That’s the way the world works. Everything is so inter-connected” (Can9_STEM).

Community of Scholars

The development of a respectful and supportive community of scholars was the second key feature of the environment as Can7_STEM reported:

> I was doing a reaction that involved pressure and I had to fill in a form as you do in Chemistry and we just couldn’t figure out what the pressure would be in the vessel when it reached the height of the reaction so I emailed an Engineering candidate [in the CDT group] and said ‘this is probably second year for you but I just can’t figure this out’…they laughed…’it’s this table, you read it off this graph here’. I could have spent a week in the library…but I had a friend over there.

The relaxed nature of the group sessions seemed to be a key. For example, at the Friday lunch time sessions it was usual for the only academic staff member present to be the Director who aimed to develop an informal and open environment as Can8_STEM explained: “It [Friday seminar] is quite informal and so you can stick up your hand and ask any question, any silly question, nobody cares as long as you are going to get a better understanding of it”. The notion of a supportive environment for doctoral candidates continued with: “Having someone present their work…and in a safe space, where there is respect where you are encouraged to question and think. You are allowed to have an imperfect response, you are allowed to fumble your way through something” (Sup4_HASS).

Perhaps the following comment summarises well the general feeling that had been engendered in the group:

> I think a lot of this is about personal relationships. There’s quite a lot of talk about structures and the philosophy of how interdisciplinary research can be seen and so on…but much of the being successful is having people who like to spend time together. (Sup7_STEM)

Institutional Environment

The third aspect of the environment reported by interviewees was the institution itself. A number of the interviewees commented specifically on the size and layout of the institution in terms of how they thought it supported a successful interdisciplinary research environment. For example, as Sup6_HASS commented, the university is: “Small and cosy [plus] we live in a small town and many students live in residence and so it is easy”.

Benefits and Challenges of working in the environment

With regard to benefits and challenges of undertaking doctoral research in such an environment there was general agreement that working in an interdisciplinary environment was more challenging than in a single discipline, complicated by issues such as the nature of universities, funding bodies and employers. For example: “The system is very department centric… so doing research across disciplines is very challenging, especially for PhDs where they focus on even sub-disciplines” (Sup1_STEM).

However, candidates reported advantages related to opportunities to share ideas with others and explain their research, although as one candidate reported: “but I wouldn’t say it is the type of thing to get involved in if you just want to do a PhD thesis” (Can1_STEM). From the experience of sharing and hearing other perspectives one candidate reported that: “Only now am I starting to see wider audiences for the work” (Can4_HASS). Many also realised how being able to explain their research to others would be helpful in future job applications and often in tangential ways. For example: “…the CDT has a great list of contacts, alumni and people who have been in touch in the past and that has been very useful” (Can4_HASS).

There was extensive agreement that in most cases candidates did not change their project as a result of being in an interdisciplinary environment. However, there were comments such as: “It was horizon widening rather than changing the actual research” (Sup1_STEM). Furthermore, many candidates such as Can1_STEM reported that by: “talking with others and having to explain my research to them and also understanding theirs I got a broader understanding of the sector”.

Working with others from different disciplines challenged some interviewees to appreciate their own views and values as well as those of others: “[It] encourages you to confront your own prejudices and turn the question around from ‘I don’t think this [your research] is of value’, to ‘why can’t I understand the value of this? (Sup4_HASS).

Additionally, such a research environment: “allows you to learn the language of another discipline. I mean there is no interdisciplinary language as such, you have to be able to be speak in the idiom” (Can8_HASS).

Some interviewees reported negatives associated with the interdisciplinary approach but the great majority reported the positives overcame any negatives: “It has been time out from writing and research and hasn’t improved the quality of my thesis, but the positives outweighed this” (Can1_STEM). Additional comments along these lines included: “It’s quite hard work and takes more time than disciplinary research even though interdisciplinary research is probably more worthwhile” (Sup3_STEM). However, Sup 4_HASS suggested: “The flip side [of the positive] is if you are exposing students to a rich smorgasbord of ideas…they will come back with an idea that has really charmed them. This can pose some challenges”.

The critical role of communication and perspective

Communication was the second critical issue arising from the interviews. Using the broad categories of STEM and HASS there were more comments from STEM participants about difficulty with understanding HASS presenters than the other way around.

> I think the challenge with dealing with social science is the terminology. People find that off-putting. For us we are dealing with fairly everyday notions and…we don’t really see why it can’t be expressed in everyday language. (Sup7_STEM)

However, while Sup7_STEM suggests that he/she and colleagues are dealing with ‘fairly everyday’ concepts, this might not, of course, be the way that HASS colleagues view it. Yet, as noted above, there were very rarely comments from HASS participants regarding difficulty with understanding their STEM peers.

It was clear that a major concern appears to be language and communication. For example: “they [social scientists] go banging on about narratives**…**they have an awful lot in one sentence” (Group2_STEM). Then as Sup7_STEM elaborates: “I think what we find difficult about work produced by social scientists, is that we don’t really see why it is necessary with

what's being written about to use that sort of disciplinary mode of communication". However, she/he acknowledges: "I think social scientists would say we [scientists] have very particular world views".

Can2_STEM certainly was aware of the difficulties of different disciplinary approaches: "It was tricky, it shouldn't be but it [social sciences] feels like a completely different science. Having no right answer is very difficult" and then adding "it's amazing how much more you need to explain things outside your own discipline—questions you don't get in your own discipline you suddenly get these bizarre left of field [questions]". Sup4_HASS adds: "I know from conversations we have had that there is a sense of bewilderment that [the candidate] encounters when not everybody 'gets' it".

Regarding communication, Can5_HASS summed it up well:

> One good example was the time I had to give a presentation… one other [student] presented and it went over my head. But when it came to my presentation I had to really think about how do people who don't study social sciences think and…what this means to them. That was quite challenging.

Furthermore, a STEM participant suggested that:

> What it does is it challenges perceptions that you have never questioned…so all of a sudden you are forced to engage with different perceptions of what you do by different groups of people. (Sup5_STEM)

There was general agreement that an important way of learning to communicate was to: "expose ourselves to each other's disciplines" (Can5_HASS) and the mini-projects were seen as particularly helpful, although challenging:

> You are put in with people like the Earth Scientist and I don't really know what they do other than smash rocks…Usually the sciencey people have a more technical background, like we have to build something whereas the social science person spent a long time discussing what the question meant. We got into something like 'we need to build a new power station'. And then what he talked about was which people were important as opposed to us who talked about what we would build. (Can6_STEM)

Several of the supervisory interviewees spoke at length regarding the assistance they had received from talking with a particular colleague who seemed to be able to assist candidates and academic staff to appreciate their various views and approaches: "[this person] can convey the different approaches in a way that is non-divisive and breaking down barriers" (Sup1_STEM). As a result, Sup4_HASS reported that: "we agree at the outset that there is something of value here. What we also agree is that we probably won't all understand what that value is. So, we have to ask some questions about why people in that community see this as valuable."

Qualities of candidates and supervisors

The third theme related to the qualities interviewees thought assisted candidates and supervisors to work effectively in an interdisciplinary environment. The most common characteristic related to being receptive, open minded and curious. As Can2_STEM suggested: "I think you've got to be a lot more open minded to do interdisciplinary work". Additionally, it was suggested that candidates needed a level of enthusiasm for engaging in

the CDT activities: “You have to be enthusiastic [but] you can’t blame people [not engaging as] their principal duty is to do a PhD and usually do it as quickly as they can” (Can8_HASS).

A particularly interesting comment came from Sup1_STEM when describing what he/she thought were the qualities of a successful interdisciplinary research candidate: “[they] have to love research as a concept rather than focussing on the topic.”

Regarding supervisor qualities, open-mindedness was the most commonly reported quality. In addition, one supervisor reported of himself being: “prepared to look like a bit of a moron” (Sup3_STEM) and another being “willing to have my own views of research challenged, explored, pulled apart” (Sup1_STEM).

Discussion and Conclusion

The particular focus of this research was to understand how candidates and supervisors experienced undertaking a discipline-related PhD but within a structured inter-disciplinary environment.

Therefore, in this section we use the findings to answer our research question and articulate some key factors for those wishing to develop an interdisciplinary training environment for doctoral or early career researchers.

It is known that interdisciplinary researchers can experience significant levels of uncertainty and lack of belonging when commencing a doctorate (Holley, 2009) and such feelings were reported by our participants. Therefore, it is not surprising that most interviewees discussed the importance of ‘actively engaging’ in the research environment and being part of a community of practice (Lave & Enger, 1991).

In terms of positive experiences almost all those interviewed recognised that there were benefits for their personal and professional development as researchers which emerge from engaging with an interdisciplinary research environment. Interviewees indicated that one of the benefits of an interdisciplinary environment is that continued engagement brings greater clarity to concepts and enables individuals to describe their work with greater lucidity to other researchers. In many ways this is the development of the language of interdisciplinarity. It is also the case that increasing engagement with interdisciplinary research results in previously hidden layers of complexity emerging as researchers consider issues which may not be prominent in their own disciplinary contexts. Interdisciplinary environments clearly enable researchers to have greater impact with their research through the ability to communicate effectively to a wider range of research communities.

An important factor which emerged from our findings is that for successful interdisciplinary research it is vital for individuals to respect different points of view. It is also clear that some of the success of this interdisciplinary environment can be attributed to the open and inclusive culture with few rules, either implicit or explicit. It was reported that this encouraged candidates to engage, experiment, explore and refine their own ideas. In such an environment experiential learning seemed to play a prominent role.

The benefits outlined above are tensioned against factors which are perceived as presenting barriers to interdisciplinary research. One barrier is that of not knowing the conventions of the group and how to communicate different world views. This required participants to work out the rules of a particular interdisciplinary environment. As noted above, a number of researchers initially struggled to find their feet in such an environment. In particular, STEM researchers reported finding it difficult to understand the emphasis on people and human

factors in HASS. It is of particular note that STEM researchers also reported finding it more difficult to adjust to HASS perspectives than vice-versa. This is an interesting phenomenon which requires further investigation.

Conclusion

In conclusion we find that the key factors enabling an effective interdisciplinary doctoral learning environment are:

1. A structure which pays careful attention to academic, administrative and structural barriers that exist between different disciplines.
2. An open, trusting and respectful environment with effective non-judgmental and non-invasive facilitation.
3. Careful selection of candidates who demonstrate an interest in, and a willingness to engage with, an interdisciplinary research environment.
4. A clearly articulated inclusive research focus around a cognate theme for the interdisciplinary group.
5. A richly varied and structured programme to enable high levels of participation which includes opportunities for researchers to interact, express their views, learn from each other and develop interdisciplinary skills.

The research suggests that, when these factors are effectively addressed, candidates and supervisors will be enabled to not only undertake their own disciplinary research but also relate that work within a broader interdisciplinary environment.

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